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(71) Applicant: RAYTHEON TI SYSTEMS, INC. [US/US]; 2501 South Highway 121, Lewisville, TX 75067 (US).

(72) Inventors: SANZGIRI, Shashikank, M.; 6840 Barbican Drive, Plano, TX 75023 (US). VOLPI, John, P.; 913 Bromwich, Garland, TX 75040 (US). VESPA, Anthony, J.; 14 Vicksburg Lane, Richardson, TX 75080 (US). GILLILAND, Paul, C.; 1109 Country Lane, Allen, TX 75002 (US).

(74) Agent: MILLS, Jerry, W.; Baker & Botts, L.L.P., 2001 Ross Avenue, Dallas, TX 75201-2980 (US).

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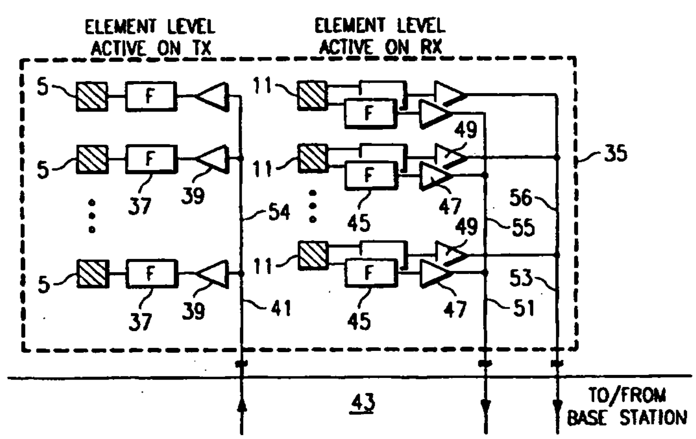
(54) Title: ANTENNA SYSTEM FOR ENHANCING THE COVERAGE AREA, RANGE AND RELIABILITY OF WIRELESS BASE STATIONS



(57) Abstract

An active antenna system which has a plurality of antenna elements arranged in a column with each element or subarray of elements integrated with an amplifier and other beam forming components. A separate amplifier and filter are disposed immediately adjacent and connected to each of the antenna elements or a subarray of antenna elements and a separate combiner/divider is connected to each of the amplifiers. The antenna elements, amplifier and filter are disposed on a common support. A base station is connected by the feed cables and is remote from each amplifier. A first group of the antenna elements with low power amplifiers forms a transmitting antenna system and/or a second group of the active antenna elements with low noise amplifiers forms a receiving antenna system. A variable attenuator and a variable phase shift circuit can be integrated with each amplifier and can be used for beam shaping and electronic beam pointing. For diversity combining, spatially separated or polarization diverse active antennas are used. For polarization diverse active antennas, implementation involves a shared column or two colocated orthogonally polarized columns.

ANTENNA SYSTEM FOR ENHANCING THE COVERAGE AREA, RANGE AND RELIABILITY OF WIRELESS BASE STATIONS

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

This invention relates to an antenna system and, more specifically, to an antenna system primarily for use in conjunction with base station in mobile communications systems.

BRIEF DESCRIPTION OF THE PRIOR ART

Mobile communication systems generally include a base station for receiving and transmitting electromagnetic radiations with the mobile terminal disposed within the coverage area of the base station for transmitting electromagnetic radiations to and receiving such radiations from the base station and where several such base stations are generally linked together through base station controllers (BSCs) and master station controllers (MSCs) to provide a seamless communication link between a mobile terminal and its calling party.

Mobile communications are typically embodied within two bands. Those systems between approximately 850 and 950 MHZ are referred to as cellular and those systems between approximately 1.8 and 2.0 GHz are referred as personal communication systems (PCSs). The total mobile applications which together cover both bands are often

from the amplifiers to overcome the insertion loss from the feed cable as well as the combiner.

For the receive configuration, the combiner output is fed to a filter/low noise amplifier (LNA) combination through either a short transmission line (as in PCS systems for mast mounted LNAs) or through a long cable (as in cellular systems for base station integrated LNAs. Dual redundant amplifiers are typically provided when mast mounted electronics are used to improve reliability at the expense of complexity. For the receive configuration, the effective noise increase contributed by the ohmic losses in the array combiner and feed cable (depending upon its length) are amplified by the low noise amplifier and thus contribute to the increase in the system noise figure.

There has been a constant desire to improve the range and coverage area capability for individual base stations used in wireless communication systems of the type described above. One way to solve this problem has been to place a redundant pair of LNAs on top of the tower and connect the LNAs to a passive (i.e.antenna elements with a combiner) antenna column with a short transmission line and a switch. The combiner loss and the switch loss still limits the receive system noise figure.

LNA is integrated with the base station and by as much as 1.5 dB where an LNA is integrated with the passive antenna column at the tower top or the mast of the antenna system.

Since a significant percentage of the effective noise degradation in the antenna system is a result of the loss in the feed cables and power combiners, it can be seen that, in the case of the receiving section of the active antenna system, the noise picked up by the feed cables is never amplified whereas this noise is amplified in the prior art system. Accordingly, a much smaller effective noise element arrives at the base station relative to the prior art system described above.

Similarly, for transmit configurations, the low power amplifiers, when integrated with the radiating elements, increase the EIRP by as much as 4.5 dB (for the same amplifier power output) over the conventional approach where the power amplifiers are integrated with the base station.

The distributed nature of the amplifiers also improves reliability since the system can be designed to be fully compliant even after failure of one or more of the receive or transmit amplifiers. Even when sufficient failures occur to reduce overall system performance, the performance degradation is graceful rather than catastrophic.

In the transmit configuration, using active antenna systems, noise in the feed cable amplified by the amplifiers is of no concern, since the signal power is several tens of dB higher than the noise power. The main advantage of active antenna systems for

orthogonal polarizations are implemented with each polarization port fed to its own filter/LNA network and combiner.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a diagram of a prior art PCN base station architecture for an antenna system for both transmission and reception of electromagnetic radiations;

FIGURE 2 is a diagram of an active antenna system architecture in accordance with a first embodiment of the present invention; and

FIGURE 3 is a diagram of an active antenna system architecture in accordance with a second embodiment of the present invention.

with polarization diversity, the same discussion applies to the receiving system utilizing spatial diversity. For the purpose of illustration,, the filter/LNA combination is shown mounted on the mast, as is the common practice for PCS base stations. As can be seen, the ohmic losses in the combiners and short transmission lines between combiners and the filter/LNA combination contribute to the degradation in the system noise figure.

Referring to FIGURE 2, there is shown an active antenna architecture in accordance with the present invention. The antenna is similar to that of FIGURE 1 except that all of the radiating antenna elements 5 and 11 are on the same support 35 and, rather than having a single filter 15 and amplifier 13 for the transmit section and the filter 19, 21 and associated amplifiers 23, 25, 27, 29 for the receive section as shown in FIGURE 1, each radiating antenna element has its own filter and amplifier positioned as closely adjacent to the antenna element as possible. This is shown in FIGURE 2 wherein, for the transmit portion, each antenna element 5 is connected to its own filter 37 and amplifier 39 with the feed cable 41 extending from the base station 43 to each of the amplifiers 39 through power divider 54. In the receive portion, each radiating antenna element 11 has two orthogonally polarized outputs as in FIGURE 1 with each output have its own filter 45 and amplifier pair 47 and 49. The outputs of the amplifiers 47 and 49 are combined in the power combiners 55 and 56 and are fed to the base station via feed cables 51 and 53 respectively. The receive configuration with polarization diversity is shown here for the

A second embodiment of the invention comprises only the receive portion of the above described structure and a third embodiment of the invention comprises only the transmit portion of the above described structure.

Though the invention has been described with respect to specific preferred embodiments thereof, many variations and modifications will immediately become apparent to those skilled in the art. It is therefore the intention that the appended claims be interpreted as broadly as possible in view of the prior art to include all such variations and modifications.

6. The system of claim 4 wherein a first group of said plurality of antenna elements comprises a transmitting antenna system and a second group of said plurality of antenna elements comprises a receiving antenna system.

7. The system of claim 5 wherein said transmitting antenna system and said receiving antenna system display a different type of diversity.

8. The system of claim 6 wherein said transmitting antenna system and said receiving antenna system display a different type of diversity.

9. The system of claim 5 wherein said transmitting antenna system and said receiving antenna system display spatial diversity.

10. The system of claim 6 wherein said transmitting antenna system and said receiving antenna system display spatial diversity.

11. The system of claim 5 wherein said transmitting antenna system and said receiving antenna system display polarization diversity.

12. The system of claim 6 wherein said transmitting antenna system and said receiving antenna system display polarization diversity.

19. The system of claim 8 further including a variable attenuator and a variable phase shift circuit connected to each said amplifier and disposed on said support.

20. The system of claim 10 further including a variable attenuator and a variable phase shift circuit connected to each said amplifier and disposed on said support.

21. The system of claim 12 further including a variable attenuator and a variable phase shift circuit connected to each said amplifier and disposed on said support.

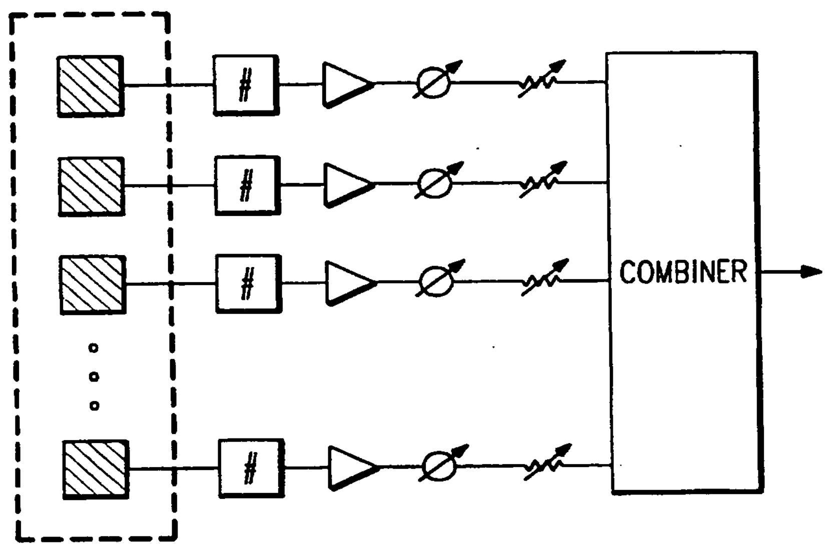


FIG. 3

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 26116 A (ERICSSON GE MOBILE INC) 28 September 1995 see page 14, line 14 - page 19, line 13; claims 1-11; figures 6,12,13	1-6
Y	EP 0 624 919 A (NIPPON TELEGRAPH & TELEPHONE) 17 November 1994 see figures 7,13,15 see figures 32,34,35 see claims 1-15	13-21
A	YAMADA Y ET AL: "BASE STATION/VEHICULAR ANTENNA DESIGN TECHNIQUES EMPLOYED IN HIGH-CAPACITY LAND MOBILE COMMUNICATIONS SYSTEM" REVIEW OF THE ELCTRICAL COMMUNICATIONS LABORATORIES, vol. 35, no. 2, 1 March 1987, pages 115-121, XP000572063 see the whole document	7-12

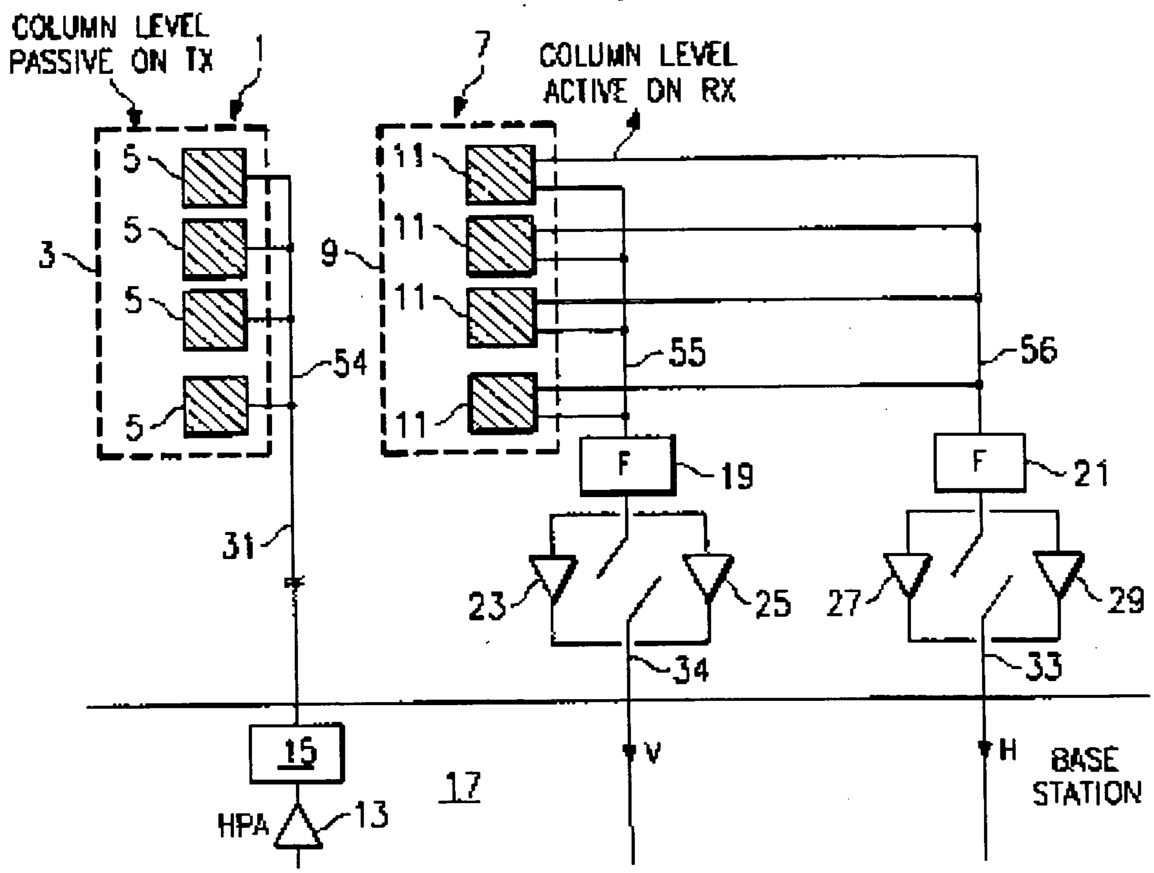

FIG. 1
(PRIOR ART)

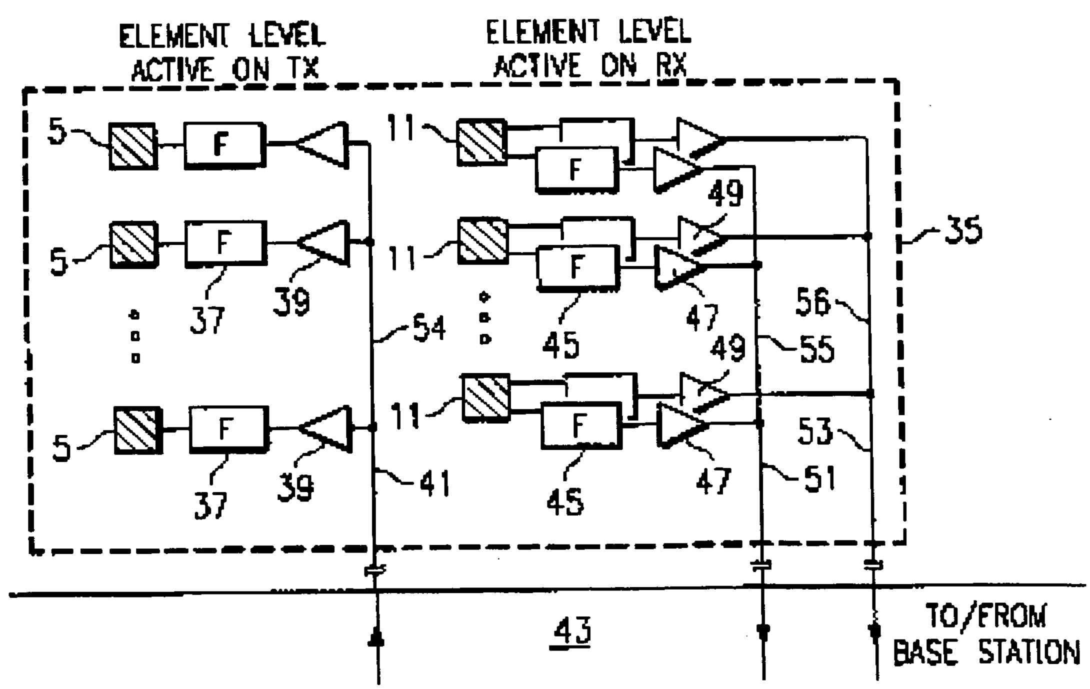

FIG. 2